
ONR
Revolutionary Research . . . Relevant Results
Sharpening the Edge
Serving the Next Generation Warfighter . . . Now
Powering Future Naval Forces
Presented by
Dr. Larry Schuette
Director of Innovation
Office of Naval Research
larry.schuette@navy.mil
www.onr.navy.mil/innovate
703-696-7118
OFFICE OF NAVAL RESEARCH

# Report Documentation Page

*Form Approved*
*OMB No. 0704-0188*



| 1. REPORT DATE | 2. REPORT TYPE | 3. DATES COVERED |
|---|---|---|
| **NOV 2010** | | **00-00-2010 to 00-00-2010** |

| 4. TITLE AND SUBTITLE | 5a. CONTRACT NUMBER |
|---|---|
| **Powering Future Naval Forces** | 5b. GRANT NUMBER |
| | 5c. PROGRAM ELEMENT NUMBER |
| 6. AUTHOR(S) | 5d. PROJECT NUMBER |
| | 5e. TASK NUMBER |
| | 5f. WORK UNIT NUMBER |
| 7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **Office of Naval Research,875 N Randolph St, One Liberty Center,Arlington,VA, 22203** | 8. PERFORMING ORGANIZATION REPORT NUMBER |
| 9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) | 10. SPONSOR/MONITOR'S ACRONYM(S) |
| | 11. SPONSOR/MONITOR'S REPORT NUMBER(S) |

12. DISTRIBUTION/AVAILABILITY STATEMENT
**Approved for public release; distribution unlimited**

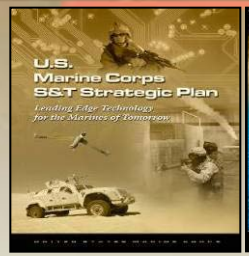
13. SUPPLEMENTARY NOTES

14. ABSTRACT

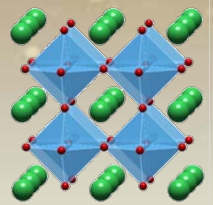
15. SUBJECT TERMS

| 16. SECURITY CLASSIFICATION OF: | | | 17. LIMITATION OF ABSTRACT | 18. NUMBER OF PAGES | 19a. NAME OF RESPONSIBLE PERSON |
|---|---|---|---|---|---|
| a. REPORT **unclassified** | b. ABSTRACT **unclassified** | c. THIS PAGE **unclassified** | **Same as Report (SAR)** | **11** | |

# Naval S&T Strategic Plan







Perovskite-based Pyroelectrics

Power Node Switching Center

Solid State Lights for Submarines

Broad

Narrow

Focus

Near

Mid

Long

Discovery & Invention (Basic and Applied Science) ≈40%

Leap Ahead Innovations (Innovative Naval Prototypes) ≈10%

Acquisition Enablers (FNCs, etc) ≈30%

Quick Reaction & Other S&T ≈10%

EMRG

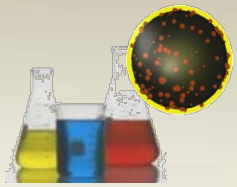
## Focus Areas

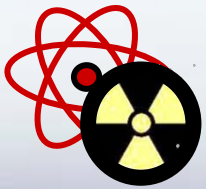
- *Power and Energy*
- Operational Environments
- Maritime Domain Awareness
- Asymmetric & Irregular Warfare
- Information Superiority and Communication
- Power Projection
- Assure Access and Hold at Risk
- Distributed Operations
- Naval Warfighter Performance
- Survivability and Self-Defense
- Platform Mobility
- Fleet/Force Sustainment
- Total Ownership Cost

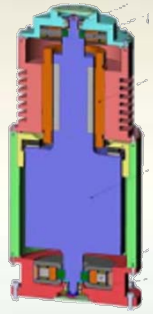
# Power & Energy Technologies

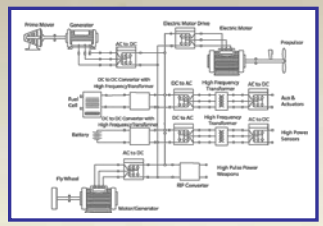
Revolutionary Research . . . Relevant Results

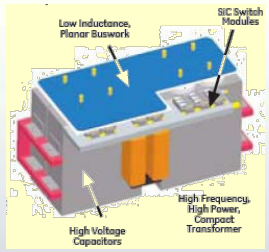
| Fuel | Power Generation | Energy Storage | Distribution & Control | Power Loads |
|---|---|---|---|---|
| Fuels Chemistry | "Ion Tiger" UAV Fuel Cell | Batteries | Electrical Architectures & Pulse Forming Networks | Electric Weapons |
| Alternative Fuels | Fuel Cells | Flywheels | High Voltage Silicon Carbide (SiC) Switches | Powering & Resistance |
| Nuclear | Aircraft Engines | Capacitors | | UV Sensor Loads |
| | Gas Turbine Generators | | | Reconfigurable Blades / Blade Loading |










# S&T Energy Investments

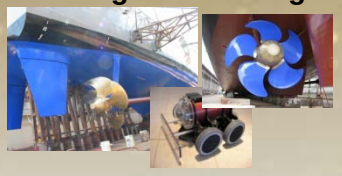
Revolutionary Research . . . Relevant Results

**Power Loads**

Solid State Lighting

Advanced Sensors

Coatings & Cleaning



Advanced Propellers

Electric Weapons

**Distribution and Control**

SiC Devices

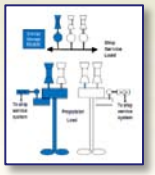
Bi Directional Power Converters

Power Management Controllers

Medium Voltage Direct Current Architecture

HTS Power Transmission Cables

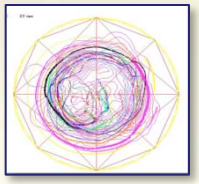
**Energy Storage**



Hybrid Electric Drive

High Density Energy Storage Advanced Batteries

Antimatter/ Particle Storage



**Power Generation**

UAV Fuel Cells

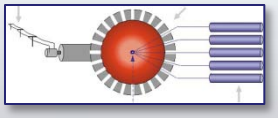
Mobile Power Fuel Cells

UUV Power

Variable Cycle Advanced Technology (VCAT)

**Fuel**





Laser Fusion

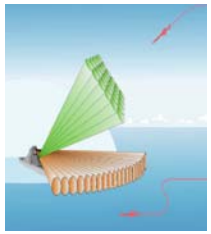
**Near** **Far**

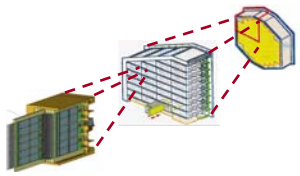
# Advanced Electric Warship
# Next Generation Integrated Power System (NGIPS)

Revolutionary Research . . . Relevant Results

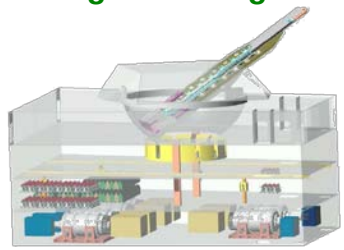
## Laser Self-Defense System

## High Power Radar

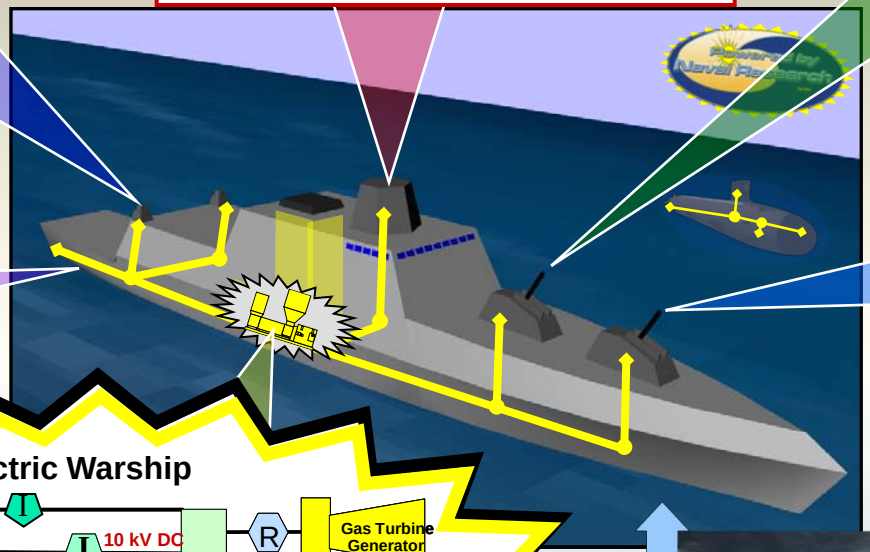




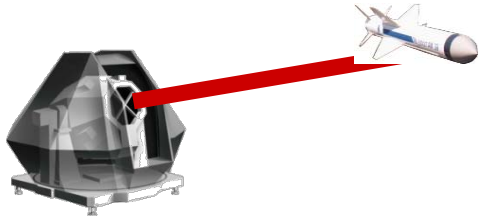
## Electromagnetic Railgun



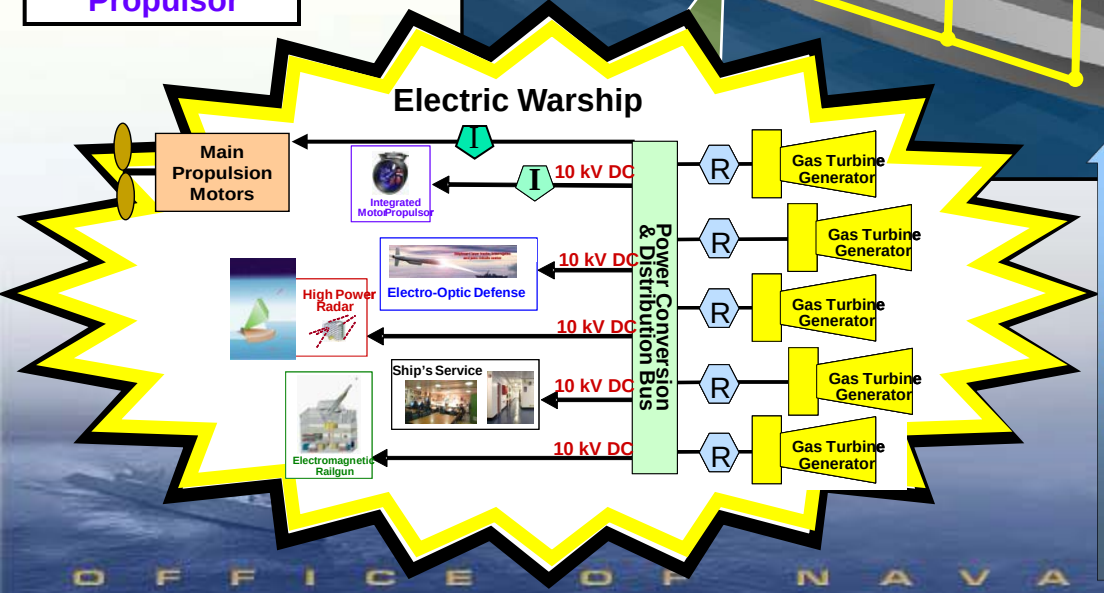
## Integrated Motor Propulsor



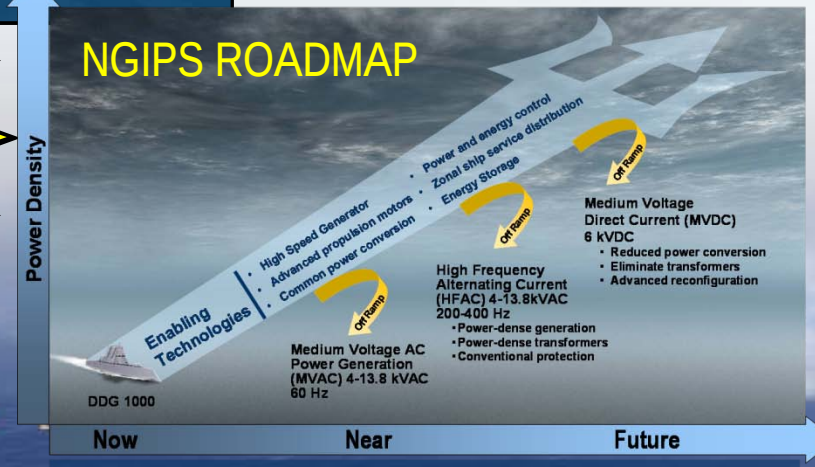
## Free Electron Laser System



## Electric Warship




## NGIPS ROADMAP



# Electric Ship Research and Development Consortium

**Consortium of universities with industry partnerships established in 2002 to address fundamental science and technology issues in power distribution and control.**


**Florida State University**

**Massachusetts Institute of Technology**

**Mississippi State University**

**Purdue University**

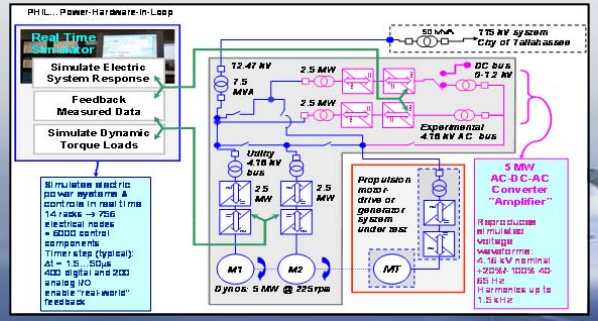
**University of South Carolina**

**University of Texas at Austin**

**U.S. Naval Academy**

***A Center for:***

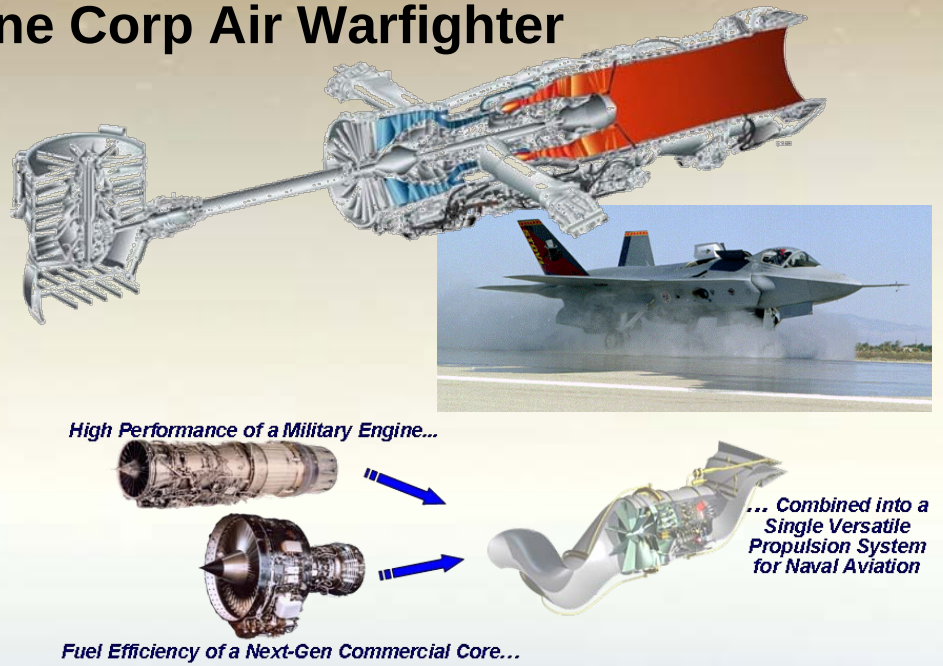
- **Hardware in the loop coupled with physics based models for system design, testing, and validation**
- **Computational tools for early-stage ship systems design**
- **Total ship system solution to thermal management**
- **Load management**
- **Next Generation Integrated Power System (NGIPS)**



# Advanced Aerospace Propulsion Science and Technology

**Develop and transition advanced airbreathing propulsion technology to the Navy and Marine Corp Air Warfighter**

- **Engine materials, coatings and processing techniques**
- **Critical propulsion system component technologies**
- **Modeling and Simulation**
- **Propulsion Health Management**




## Payoffs:

**Reduced fuel consumption**

**Lower life cycle costs**

**Higher performance and increased durability**

**Improved environmental compliance**

# Expeditionary Portable Power

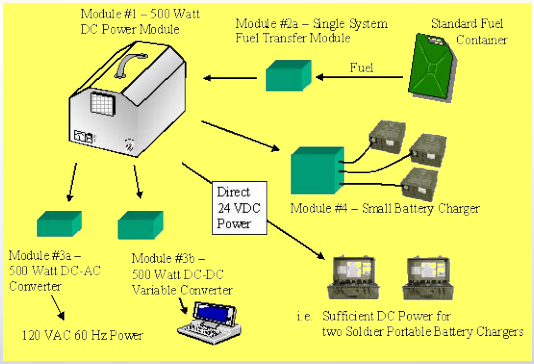
## *Solid Oxide Fuel Cell for Tactical Vehicle APU and Towable Generator*

**Efficient, low emission, and low signature**

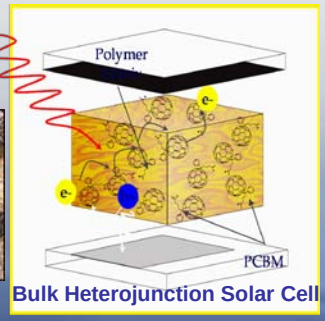
Solid Oxide Fuel Cell

Vehicle Based

Towable Power




GREENS – Ground Renewable Expeditionary Energy System



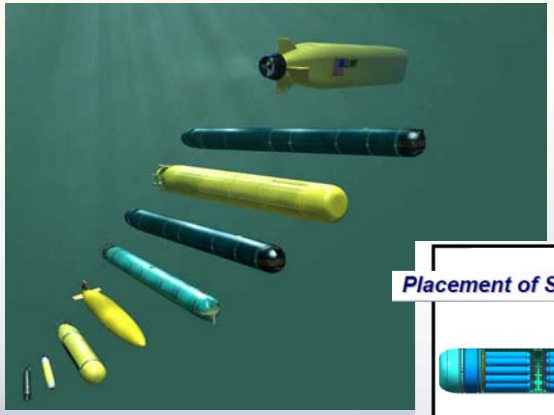

Bulk Heterojunction Solar Cell

## *Man-Portable Power Generation*

# Unmanned Systems Power

## *Unmanned Air Vehicle Power*

- **Long endurance fuel cell power (26hr flight Nov 2009)**
- **Low noise & heat signature**
- **Affordable**


## *Unmanned Undersea Vehicle Power*

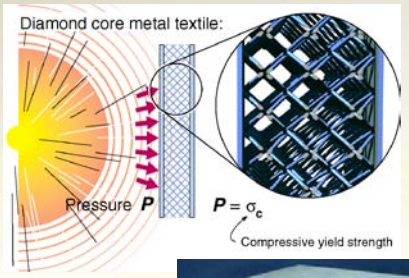
- **Lithium-ion battery safety**
- **Long endurance , air independent power systems**

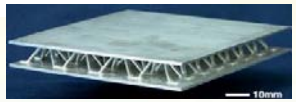
# Synergy: Energy Efficiency & Affordability

- ***Anti-Biofouling Coatings & Hull Husbandry***
- ***Lightweight Structural Materials***
- ***HTS Degaussing Cable***
- ***Turbine Engine Materials Systems***
- ***Corrosion Prevention and Mitigation***
- ***Advanced Shipboard Water Desalination***
- ***Nano-Ceramic Coatings for Life-of-System Wear Surfaces***

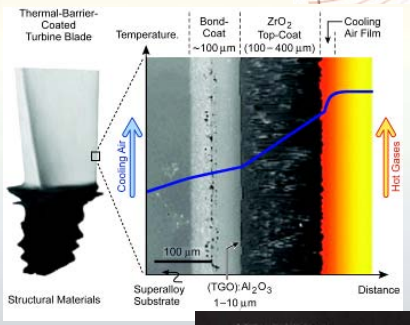
Hull Bug

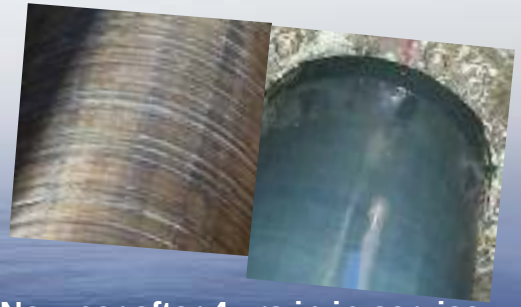
HTS Degaussing Cable



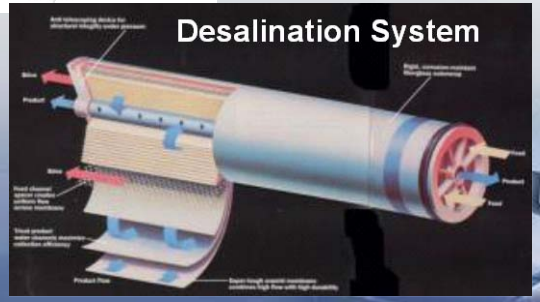



*Al-alloy formed pyramidal core*



No wear after 4 yrs in-service



# Summary

- **Broad portfolio of research in power, energy and thermal with applications across sea, land, and air systems**
- **Partnerships with industry academia and government with strong international engagement**
- **Holistic approach to efficiency (demand reduction plus improved systems)**
- **Key areas of technical interest: distribution and control, energy storage, hybrid systems**
- **Focus on: optimized platform efficiency, extending unmanned missions, providing adaptive networks, and enabling integration of high power sensors and electric weapons**